Detection of Breast Cancer in Women After Augmentation Mammoplasty Using Fluorine-18-Fluorodeoxyglucose-PET

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The purpose of this study was to determine the feasibility of FDG-PET imaging in women with silicone implant augmentation mammoplasties where mammographic detection of breast cancers is challenging due to the implants' radiodensity, which can obscure tumor visualization. **Methods:** FDG-PET imaging was performed in two women with augmentation mammoplasties and small palpable breast abnormalities. Mammograms with and without breast displacement were also performed. **Results:** PET clearly demonstrated focal FDG accumulation in the suspicious breasts, corresponding to tumors of less than 1.5 cm in diameter. There was no degradation of image quality by the implants and no need for breast displacement views. By contrast, implant displacement mammograms were necessary to fully delineate the tumors. **Conclusion:** While mammograms with displacement views represent the initial choice for imaging the augmented breast, FDG-PET can image tumors in the augmented breast without implant displacement and without obvious degradation of image quality by the implant. FDG-PET warrants additional evaluation as an adjunctive study in the augmented breast, particularly when displacement mammographic views are not adequate or are impossible to perform due to peri-implant capsule formation.

Key Words: breast cancer; positron emission tomography; glucose analogs; augmentation mammoplasty; mammography; silicone implants; FDG

J Nucl Med 1994; 35:872–875

Over one million women have received silicone gel breast augmentation implants in the past two decades (*1*). Although implantation of these prosthetic devices has been largely suspended in the United States, a major challenge remains in detecting breast carcinomas in their earliest stages in women with implants, as silicone implants are radioopaque to the low energy x-rays used in mammography (*2–3*). Indeed, newly diagnosed breast cancers in women with implants have been reported to be more advanced at presentation than newly diagnosed cancers in women without implants, probably due to the difficulties in diagnosis (*3*). A variety of methods for displacement of the implants posteriorly (and breast tissue anteriorly) during mammography have been described to improve visualization of the breast parenchyma. Unfortunately, these views do not evaluate the entire breast, can be uncomfortable and impossible to perform if capsular contractions are present, thus failing to detect some breast cancers (*4–7*). Magnetic resonance imaging (MRI) has been performed in augmented breasts, but specificity appears to be poor (*8*).

Recently, the feasibility of imaging primary and metastatic breast carcinomas using PET with cyclotron-produced FDG as the radiotracer has been demonstrated (*9–11*). With FDG-PET we were able to detect 100% of breast carcinomas in our initial clinical series (25/25 known lesions), however many of these were relatively large lesions, (*9–11*). We recently applied FDG-PET to the diagnosis of breast cancer in two women with silicone breast implants to determine the feasibility of the method and report here on these cases.

CASE REPORT

Patient 1

A 42-yr-old female had bilateral breast augmentation performed using silicone implants 6 yr prior to this hospital visit. She had moderate difficulties with capsule formation which required capsulotomy and implant revision relatively soon after the initial implantation, with subpectoral implants then being placed. She noticed a nodular region in her right breast on self-exam. Mammograms were performed, and, particularly with prosthesis displacement views, a 2.0 × 1.2 cm irregular mass was observed at the 10 o'clock position in the right breast. This was considered highly suspicious for carcinoma (Fig. 1A, B). On physical exam, a 1.5 cm mass was palpable, with no evidence of regional adenopathy or other masses. After written informed consent was obtained, an FDG PET scan was performed using previously described methods (*11*). Initial transmission images showed the prostheses to have an attenuation for 511 keV photons comparable to that of normal soft tissues (PET-measured prosthesis attenuation was 86% of normal liver attenuation). The patient was then

Received Aug. 18, 1993; revision accepted Feb. 10, 1994.

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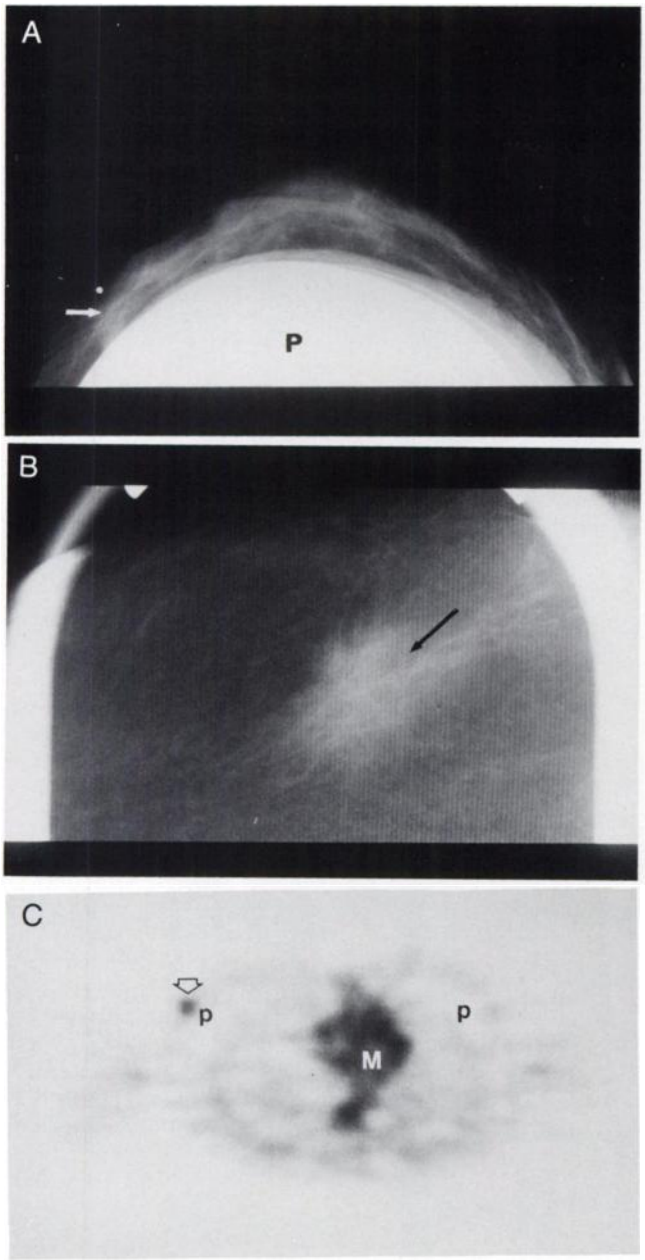

FIGURE 1. (A) Craniocaudal mammogram of the right breast with a spherical metallic marker placed over the region of palpable abnormality. The edge of the mass (arrow) is noted as is the radioopaque prosthesis (P). (B) Coned compression displacement view of the breast parenchyma under the metal marker illustrates a highly-suspicious 1.5 cm irregular mass (arrow). (C) Transverse emission PET scan at the level of the right breast abnormality demonstrates intense focal uptake (arrow). This was surgically-proven to be cancer. Central thoracic activity is residual ^{18}F activity in the mediastinum, great vessels and heart (M).

injected with 10.2 mCi of FDG and images obtained as described above. Emission PET scans showed obvious focal activity in the right breast soft tissues just lateral to the midline and slightly cephalad to the nipple. This focal uptake corresponded directly to the small palpable abnormality (Fig. 1C). The maximal standardized uptake value (SUV) in the lesion was 1.78 with an influx constant (Ki) of .0079 ml/cc/min of FDG, determined noninvasively, without correction for count recovery (*12*). Bilateral areas of diminished uptake of FDG were identified on the emission PET images which corresponded to the breast implants (Fig. 1C) immediately beneath the focal tumor uptake. Focal activity was not identified in the patient's right axilla or elsewhere to suggest the presence of regional metastatic disease. At the location of the PET scan abnormality in the right breast at surgery invasive carcinoma with both ductal and lobular features was identified. None of 11 lymph nodes in the right axilla were involved with tumor, consistent with the negative PET scan of this region.

Patient 2

A 47-yr-old female had bilateral breast augmentation procedures performed 2 yr prior to her present illness. She was presented for evaluation of an ill-defined nodular mass she had discovered on self-exam in the upper (12 o'clock) region of her left breast. On physical exam, this nodular mass was about 1.5 cm in diameter but poorly-defined. She had no clinical evidence of adenopathy. On mammography, a moderately well-circumscribed 1.5 × 1.0 cm mass with two microcalcifications corresponding to the physical examination abnormality was noted. The mammographic differential diagnosis included fibroadenoma or cancer (Fig. 2A, B). After providing written informed consent for study entry, transmission PET images demonstrated that there was similar attenuation of 511 keV photons by the breast prosthesis as was seen in normal soft tissues (PET-measured prosthesis attenuation of 511 keV photons was 86% of that of liver). The emission FDG PET scan showed intense focal increased ^{18}F activity within the left breast located superficial to large silicone implants which contained no identifiable ^{18}F activity (Fig. 2C). The maximal SUV in the lesion was 2.12, with the maximal influx constant of 0.0089 ml/cc/min, which likely represents underestimates of the "true" values due to lack of correction for incomplete count recovery by the PET scanner from the small breast lesions (*12*). It should be noted that corrections for incomplete count recovery assume homogeneous tracer uptake in the lesion and a regular lesion size, neither of which was definitely present here. No increased axillary ^{18}F activity was identified on the PET scan. At surgery, the breast lesion corresponded in size (1.5 cm maximum diameter) and location to the PET scan abnormality and multifocal intraductal and invasive ductal carcinoma was found. All 16 lymph nodes removed from the left axilla were uninvolved with tumor.

DISCUSSION

These two cases demonstrate that FDG-PET imaging of breast cancers is feasible in women with silicone breast prostheses in place. This is of potential clinical relevance as the diagnosis of cancer in the breasts of women who have undergone augmentation mammoplasties remains challenging, even with mammographic displacement techniques. Despite the compression method, the breast is often not fully-evaluated during mammography due to the presence of the radioopaque prostheses (*3–7*). The problem is even more serious in women who have received subglandular augmentations which are located anterior to the pectoral muscles (as these implants interfere even more with imaging than the subpectoral implants), or in women with capsular contractures (*6,7,13,14*). In the two cases discussed above, PET scanning with FDG easily detected lesions that were incompletely visualized on the nondisplacement view mammograms.

The technical feasibility of PET in these patients appears to be due to the fact that the PET technique relies on the detection of pairs of high-energy photons emitted from the decay of a positron emitter, in this case, ^{18}F. While some of the ^{18}F derived 511 keV photons are attenuated by the silicone implants, measured attenuation of the high energy of photons is similar to the attenuation of normal soft tissues. This lack of attenuation by the implants is in marked contrast to the substantial absorption of the low energy (26–30 keV) x-rays used in mammography and the resultant opacity of such implants on mammograms, which makes the detection of some cancers impossible. In addition to imaging "through" the prosthesis due to the high energy photons, PET also can image "around" the implants with tangential photon pair detection in which neither photon interacts with the prosthesis. These two factors appear to allow for the detection of FDG-avid cancers in augmented breasts.

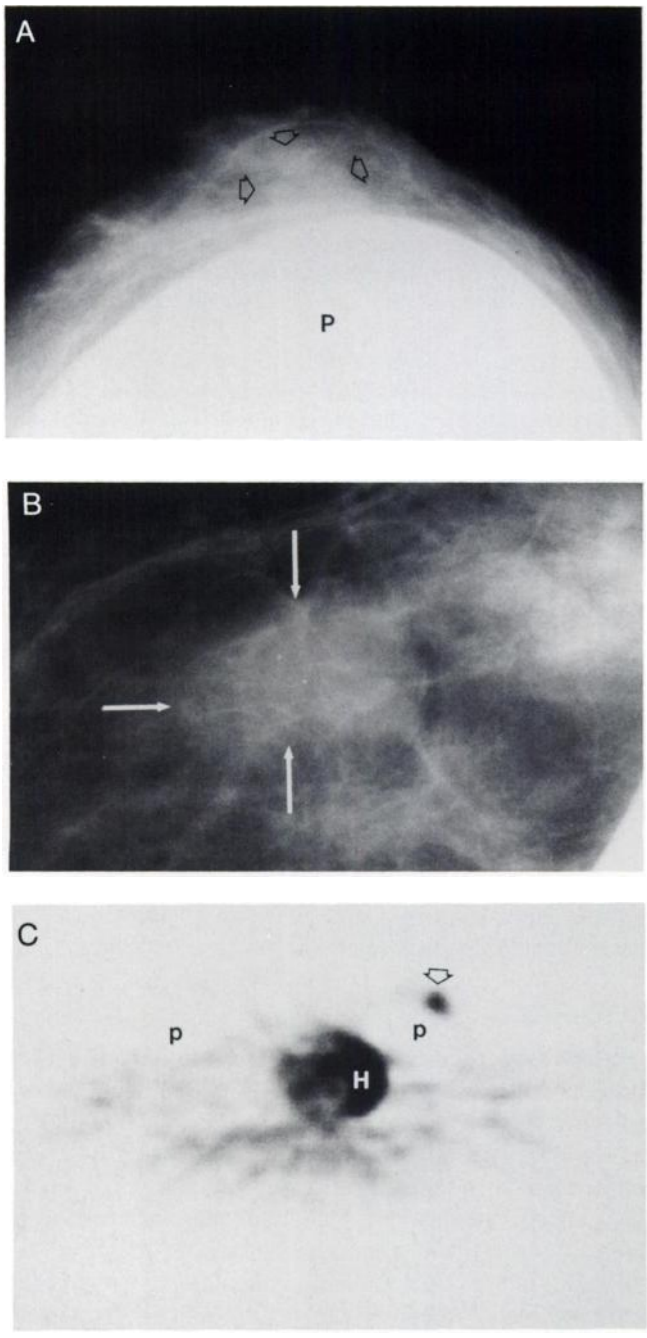

FIGURE 2. (A) Craniocaudal mammogram of the left breast shows large prosthesis (P) and adjacent mass (arrowheads). (B) Magnification coned compression displacement view of a left breast mass. The 1.5 × 1.0 cm mass (arrows) is moderately well circumscribed and has two microcalcifications. (C) Transverse FDG-PET scan at the level of the mass demonstrates an FDG-avid nodule (arrowhead) in the left breast beyond the prosthesis (P), which does not accumulate ^{18}F. Normal intense FDG uptake in the heart muscle is noted (H).

These two cases demonstrate that relatively small primary breast cancers were easily detected by PET without physical displacement of breast tissue or the prostheses. Further, images of the axilla correctly indicated the absence of axillary nodal involvement with cancer, though this application needs more study. These results are consistent with our initial reports and with a recent report by Adler in women with non-augmented breasts, suggesting good accuracy of PET in women with suspected breast cancer (*11,15,16*). Clearly, much larger studies of PET will be necessary to define this technique's role in breast cancer management and its accuracy for evaluating breast masses, especially in the augmented or reconstructed breast. Although these two cases demonstrate feasibility, additional study of the FDG-PET technique in women with silicone implants will be needed to determine its clinical utility.

ACKNOWLEDGMENTS

We thank Barbara Burton for her excellent secretarial assistance. The contributions of Dr. Michael Kilbourn, the PET chemistry staff and the efforts of the PET technologists are greatly appreciated. Referrals from the multi-disciplinary Breast Care Center are also appreciated. This work was supported by CA 52880.

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Condensed from
30 Years Ago:

The Distribution of Rubidium-86 in the Dog Heart

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The determination of ^{86}Rb distribution in vivo might offer a possibility to follow its uptake by functioning heart muscle under several experimental conditions of normal or abnormal heart activity. Such a measurement presents some difficulties in that there is not, as yet, a method equally accurate to the one available for postmortem studies.

During this investigation, an attempt was made to measure regional ^{86}Rb uptake during open-chest experiments in the dog and to follow it under several experimental conditions.

After the preliminary testing of the method, 20 mongrel dogs weighing 6-16 kg, were anesthetized with sodium pentothal (20 mg/kg). Following intubation of the trachea, the chest was opened on the left side. A catheter (no. 7 F) was introduced into the left auricular appendix. The same counter used for the in vitro experiment was placed alternatively at four different points of the anterior surface of the ventricles. While the counter was over each one of these positions, a rapid injection of 1 μCi ^{86}Rb per kg of body weight in 1 ml of isotonic glucose was given through the catheter. After four injections—one for each position of the catheter—the Geigher-Müller was "walked" over each one of the four points and a continuous recording was obtained. The infusion of ^{86}Rb was then started through the same catheter at a rate of 0.1 μCi in 1 ml of isotonic glucose.

In 10 animals, ^{86}Rb uptake was followed at the four points mentioned until the death of the animal by inducing respiratory anoxia (three experiments) or after intravenous infusion of large amount of fluids (seven animals). In the other group of 10 animals, the anterior surface of the heart was scanned with the counter before and after ligation of the descending branch of the left coronary artery.

After a single injection, the uptake of ^{86}Rb by the ventricular myocardium was higher on the left side of the heart than on the right; uptake at the base of the left ventricular was the highest of all. The same distribution pattern was observed when the counter was walked over the ventricular myocardium as well as during continuous infusion. Following ligation of the artery, the uptake of the corresponding area remained almost equal to the pre-ligation level.

Measurements showed a constant difference in ^{86}Rb uptake between areas near the apex and areas near the base of the left ventricle. There is no first-hand explanation for this phenomenon.

In vivo measurements of regional myocardial ^{86}Rb uptake were performed in dogs with the chest open, using a small ophthalmic-counter. Myocardial tissue specimens from several regions of the ventricular wall were also measured in a well-type counter. The preponderance of the left ventricular uptake against that of the right ventricular wall were also measured in a well-type counter and confirmed.

There was no uniform premortal change in ^{86}Rb distribution over several regions of the ventricular wall.

J Nucl Med 1964; 5:154-160